Artificial Intelligence in Colonoscopic Polyp Detection and Characterization: Merging Computer Technology and Endoscopic Skill for Better Patient Care

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Abstract

Artificial intelligence (AI) is a computer technology for mathematical modeling that uses nonlinear statistical analysis. While multilayer perceptron network is used for prediction of clinical outcome, convolutional neural network is used for detection of lesion in an image and its classification. In this issue of the journal, an article reviewed the impact of AI in colorectal polyp detection and characterization. This is an upcoming area of gastroenterology, which has already reached the doorstep of practicing clinicians and in the near future, it may bring a paradigm shift in clinical practice. It is expected that this thought-provoking review will stimulate endoscopists to take up research in this important field of application of an AI-based computer technology for endoscopic detection of gastrointestinal lesions.

Keywords
- Deep learning
- Artificial neural network
- Convolutional neural network
- Nonlinear modeling
- Colon cancer

Artificial intelligence (AI) is a computer technology for mathematical modeling that uses nonlinear statistical analysis as compared to linear relationship evaluated during conventional prediction systems such as logistic regression analysis to identify the relationship between input and outcome variables using pattern recognition techniques (►**Fig. 1A** and **B**).[1] Several clinical outcome predictions are done using multilayer perceptron (MLP) networks (►**Fig. 1C**).[1,2] Since perception at different levels within the network (the hidden layers) leads to correct prediction or classification, this is called the MLP network (►**Fig. 1C**). This is quite similar to the function of human brain (►**Fig. 1D**). In contrast to MLP, the lesion identification and its characterization from various images is done by convolutional neural network (CNN) technology, which uses multiple filters to classify the data.

Artificial neural network (ANN) is a form of AI that utilizes mathematical models having structure and functions somewhat similar to human brain (►**Fig. 1C** and **D**).[1] The most commonly used network in medical science, the MLP network, works in the following manner.[1] First, the network gets trained using the data from patients, whose outcome are known to the network. The network attempts to make prediction from the data that are fed to it as input variables, which is called the feed-forward network.[1] If the prediction becomes incorrect, by back-propagation, the network adjusts the weight of the interconnections to provide more correct prediction (►**Fig. 1C**).[1] Advantages of AI as compared to conventional statistical methodology such as logistic regression are presented in ►**Table 1**.[2]

However, for identification of an image and recognition of its pattern using AI is undertaken by CNN rather than

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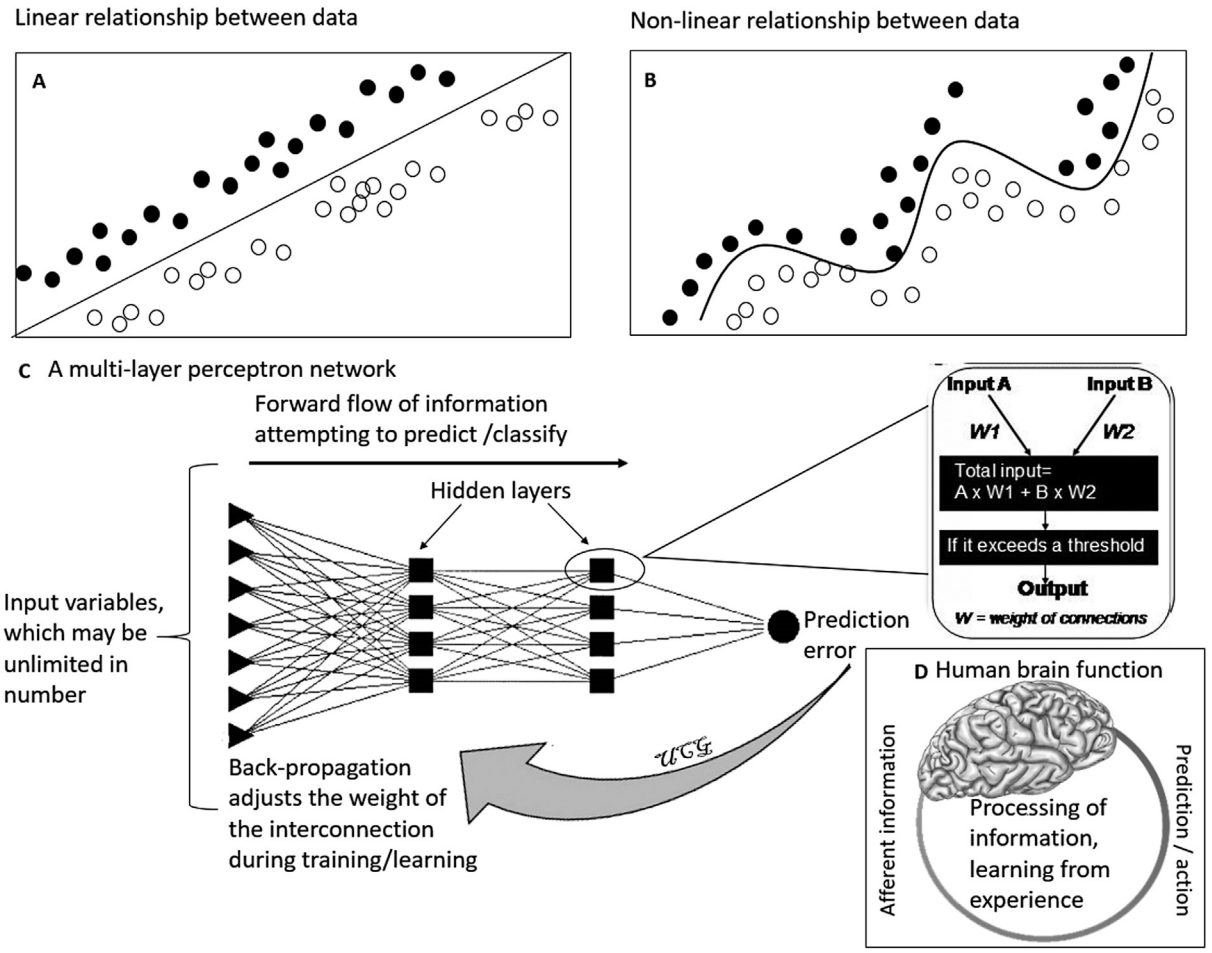

Fig. 1 . Schematic diagrams showing the principles of linear (**A**) and nonlinear relationship (**B**) between the data, function of multilayer perceptron network (**C**), which is akin to that of human brain (**D**).

Table 1 Advantages of artificial intelligence (AI) as compared to conventional statistical methodology

Parameters	Logistic regression based models	Artificial intelligence-based models
Modeling principle	Linear model	Nonlinear models
Number of parameters as input variables	Limited number, typically those significant on univariate analysis	Any number
Dynamicity	Nondynamic. Once developed, it does not improve further	Dynamic (it never stops learning)
Floor and ceiling effect	It is an usual limitation	No such limitation
Predictive accuracy	Less	More
Robustness and external validity	Usually less	Usually more

MLP.[2] ►**Table 2** lists the differences between CNN and MLP.[2] In this issue of the journal, Afzalpurkar et al reviewed the impact of AI in colorectal polyp detection and characterization.[3] This is an upcoming area of gastroenterology, which has already reached the doorstep of practicing clinicians and in the near future, it may bring a paradigm shift in clinical practice.[4,5]

A busy endoscopist performing multiple colonoscopies throughout the day is expected to be tired toward the later part of the day.[6,7] In the aviation sector, international law does not permit the pilots to be put on duty beyond a particular number of hours each day; in contrast, doctors have to continue to discharge their duties continuously over unlimited number of hours. Studies have demonstrated that colonoscopies done in the afternoon were more often incomplete and missed findings than those done in the morning hours.[6,7] Can machine-driven rather than human-driven system bring a solution to it in the face of lack of adequate doctor–patient ratio in many countries not allowing limiting the number of hours of doctor's duty immediately? The initial AI-assisted colonoscopy, GI Genius, was developed by Medtronics with annotated colonoscopy

Table 2 Differences between multilayer perceptron (MLP) and convolutional neural network (CNN)

Feature	MLP	CNN
Input data	Suitable for structured data, such as tabular data, where the relationships between features are not spatially organized	Designed for grid-like data, primarily images, where spatial relationships between pixels are crucial
Architecture	This feed-forward neural network consists of an input layer, one or more hidden layers, and an output layer. Each neuron in a layer is connected to every neuron in the subsequent layer, and there are no connections within the same layer	It includes convolutional layers, pooling layers, and fully connected layers Convolutional layers use filters to scan across input data, capturing local patterns, and pooling layers reduce the spatial dimensions
Parameter sharing	Each neuron in a layer is independent of the others, and there is no parameter sharing between them	Convolutional layers use shared weights (filters) across different spatial locations. This allows the network to learn spatial hierarchies of features
Translation invariance	Lacks translation invariance, meaning it may not perform well when presented with the same pattern at different locations in the input	CNNs exploit local connectivity and parameter sharing, leading to translation-invariant features. This is especially useful for tasks like image recognition
Use	Commonly used for tasks like tabular data regression or classification where the input features are not spatially correlated	Well-suited for image classification, object detection, and other tasks involving grid-like data
Training data	Often requires a large amount of labeled data to generalize well	Can leverage pretrained models on large image datasets and fine-tune for specific tasks with smaller data sets
Strengths	Versatile, can be used for a wide variety of tasks	Very effective for tasks that involve spatial data
Weaknesses	Not well-suited for tasks that involve spatial data	Not as versatile as MLPs

videos obtained from a colonoscopist and several AI experts working with gastrointestinal (GI) academicians.[8,9] This systems learned by iteration to place a green box on any polyp-like lesion drawing the attention of the endoscopist to see that area more carefully. This is done by pattern recognition by various optical and digital characteristics of the image and prior experience of the network. The network learned to recognize a polyp-like lesion from prior training from multiple annotated colonoscopy videos supplied by the colonoscopist to the endoscopy company developing the GI Genius technology. This was the first AI-assisted colonoscopy approved by U.S. Food and Drug Administration. Subsequently, several other manufacturers developed such AI-based colonoscopy systems. The review by Afzalpurkar et al in this issue of the journal elucidates the development, key studies, and limitations of computer-aided polyp detection system and computer-assisted diagnosis system for the detection and characterization of colonic polyps.[3]

Evidences supporting the role AI on diagnosis of the colorectal polyp have been reviewed quite comprehensively in the paper by Afzalpurkar et al in this issue of the journal.[3] The authors reviewed the development, key literature, and limitations of computer-aided polyp detection system. Since polyps differ on their malignant potential and hence, management depending on whether these are adenomatous with or without dysplasia or nonadenomatous, predicting histology of the polyp from the endoscopic features is of utmost importance. The article in the current issue of the journal also elaborates on the current status of computer-assisted diagnosis system to characterize the polyp further.[3] The current review is therefore of considerable importance to the endoscopists involved in care of the patients with colorectal polyps and those who are into research in this field. There are a few other reviews published recently that summarized and meta-analyzed the current literature on use of AI in lower GI endoscopy.[9–11] Though India has made phenomenal progress in computer technology both in the field of hardware and software, publications in relation to use of AI in the field of GI endoscopy are quite limited.[12] It is expected that the thought-provoking review by Afzalpurkar et al will stimulate endoscopists to take up research in this important field of application of an AI-based computer technology to endoscopic detection of GI lesions.

Authors' Contributions
U.C.G.: Literature review and review of the paper in relation to which this editorial is written, and writing the first draft of the paper. S.C.: Critical input while writing the first draft and subsequent editing of the paper. M.K.G.: Critical input and editing of the manuscript.

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